Andreev-bound states and supercurrents in diffusive and ballistic conductors

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We investigate the current-phase-relation (CPR) of long diffusive superconductor-normal metal-superconductor (SNS) Josephson junctions in thermodynamic equilibrium and under microwave irradiation. While in equilibrium good agreement with the predictions of quasiclassical theory is found, we observe that the shape of the CPR can be strongly affected by microwave irradiation. Our results can be understood in terms of microwave excitation of low-lying Andreev bound states above the mini-gap in the junction, and resolve a long standing inconsistency between previous experimental data and the quasi-classical theory. In a second series of experiments we study Josephson junctions with InAs-based ballistic channels as weak link. A 4-terminal contact geometry in the InAs-quantum well allows the separation of the transparency of the InAs-channel and the Nb/InAs-interface. The Nb/InAs-bilayer can be treated as an effective superconductor, which is characterized by the McMillan-energy of the interface rather than the energy gap of the niobium. Measurements of the differential conductance as well as a critical current density demonstrate a strong suppression of the Andreev reflection amplitude by relatively small parallel and perpendicular magnetic fields.